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Electric Bond and Share Company.
The Commercial development of the
Electric Light and power industry.

The Commercial Development

of the

Electric Light and Power Industry

Presented with the Compliments
of the
Electric Bond and Share Company

Prepared by
Edward B. Lee, Statistician for the Electric Bond and Share Company
June 1, 1911

This pamphlet was presented to the members of the National Electric Light Association on the occasion of the Annual Convention, held in New York City, May 29 to June 2, 1911.

ELECTRIC BOND AND SHARE COMPANY.

The Commercial Development of the Electric Light and Power Industry

During the period extending from the days of youth of most readers of this pamphlet to the present time there have been the greatest achievements ever known in the electrical field. The last half century has witnessed the birth of the telephone, the perfection of the telegraph, the discovery of the arc and incandescent lamps, the innovation of the alternating current, the inventions of the many devices of the central electric station, the inauguration of electric street railroads, the discovery of wireless telegraphy, the use of the electric ignition spark, making possible the automobile, flying machine and motor boat, and the application in dozens of other ways of the force of electricity.

No other influence has ever exerted such power on industrial life as that brought into existence by these discoveries and inventions in electricity. In fact, our whole industrial life has been made over by the electrical development of this period. The industrial changes are still going on and will become even more pronounced with the cheapening of electrical energy through the use of water power.

The members of the National Electric Light Association naturally are more interested in a discussion of central electric stations than in any other development in the electrical field. Naturally, too, they are more conversant with the facts relative to the development of the present central electric station and the vast work it is now doing. Therefore mere mention of the more important points is all that is necessary by way of introduction.

The electric light business, from a commercial standpoint, has been entirely a growth of a third of a century. Despite its youth, however, it is an all-important factor in the industrial world. In the United States alone there are at present in the neighborhood of 6,000 central electric stations, not including the thousands of isolated plants and those

devoted to street railway purposes. These stations have been erected at a cost of approximately two billion dollars and have an aggregate yearly output of ten and one-half billion kilowatt hours.

The beginning of the electric light and power industry in the United States dates from 1879, in which year Charles F. Brush put into practical use his first series of arc lamps in Cleveland, Ohio. Soon afterward local electric lighting companies were organized in various parts of the United States to make use of the Brush system. The credit for being first to install a central station to operate arc lamps by means of the Brush system belongs to the California Electric Light Company of San Francisco.

Previous to Mr. Brush's successful effort there had been many experiments and numerous public tests of electric lighting. As far back as 1808, Sir Humphry Davy, then an assistant lecturer in the Royal Institution in London, demonstrated the practicability of Volta's theory of obtaining electricity from cells consisting of unlike metals immersed in a liquid, and was one of the first to apply this new source of power to the investigation of the elements. In 1844 Foucault, a French physicist, experimented with carbon deposited in gas retorts, and by using this in connection with the Bunsen battery was able to produce such a steady and continuous light as to make the process applicable to photographic purposes. Prof. B. A. Stillman, Jr., and Dr. W. H. Goode, with the help of Yale College's 500-cell battery, also in the early forties, made satisfactory experiments in obtaining photographic impressions by light reflected from the surface of a medallion to the iodized surface of a daguerreotype plate.

In 1852 E. S. Staite, an Englishman, met with some success in an experimental lighting of streets in several English towns, while in 1855 LaCassagne and Thiers, employing a column of mercury and special mechanism to lift and feed the carbons, lighted, as an experiment, one of the public squares of Lyons, France. The first patent for a dynamo electric machine was granted in 1870 to Z. T. Gramme, a Belgian. This

first dynamo electric machine, like other machinery of a similar character, was based primarily upon the principle discovered by Faraday, according to which if magnets or coils of wire be constantly changed with relation to each other, electric currents are generated, the current depending upon the strength and number of magnets, the velocity and direction of their movements and the number of coils or the turns of wire in each one of them.

In 1876 Jablochkoff introduced his arc lamp. This lamp, more simple than any preceding it, consisted of two vertical parallel sticks of carbon separated slightly by an insulating material which was consumed at the same time as the carbons. They burned best with an alternating current, which insured an even consumption of the carbons. Jablochkoff patented his lamps all over the world and soon they were used in several communities. Another important achievement at this time was that of William Wallace and Prof. Moses G. Farmer, who exhibited at the Philadelphia Centennial Exposition of 1876 the only dynamo that supplied current for use in any way for the illumination of the exposition.

It was in 1877 that Thomas A. Edison, following his inventions in the telegraph and telephone field and in the same year that he invented the phonograph, took up for solution the problem of producing electric light by an incandescent filament. It will be recalled that in 1879 Charles F. Brush established an arc lamp system in Cleveland and that soon afterward numerous local companies were organized to make use of the Brush system.

The problems Edison set himself to solve were two in number, namely, the subdivision of electric current into many small units and the invention of a commercially practical incandescent burner for a lamp. The question of the subdivision of electric current had been studied by many scientists for a quarter of a century and had been abandoned by them as impracticable. By the latter part of 1879 Edison had solved the problems and had installed at Menlo Park, N. J., where he had had his laboratory for several years, the first complete system of

incandescent lighting in the world. After many trials he had succeeded in carbonizing a piece of cotton sewing thread, bent it into a loop form and sealed it into a glass globe from which the air had been exhausted until a vacuum up to one-millionth of an atmosphere had been produced. It proved an experimental success. He then substituted carbonized paper for the sewing thread with even better results. Between October 21, 1879, and December 21, 1879, several hundred paper-carbon lamps were made and used in his Menlo Park lighting system.

The fact that in 1902 there were 20,000,000 and in 1907 46,000,000 incandescent lamps in service and that in 1911 there will be approximately 90,000,000 manufactured, tells the story of Edison's success

The Edison incandescent lamp came as a surprise to the scientist and the public alike, as a blow to the gas lighting industry and as an irritating circumstance to those interested in arc lamp lighting. For several years following its invention the introduction of the incandescent lamp was bitterly fought by the arc lamp and gas lighting interests. Fortunately, however, not many years passed before it was recognized that all these interests would be best served by working in harmony.

It is not surprising that there should have been the early antagonism between those representing the arc lamp and the incandescent lamp, for the two systems were in many respects radically opposed to each other fundamentally. Neither is it surprising that in the end the two systems came into close working agreement. Arc lighting, with its high voltage and large units of harsh light, was best suited for exterior use, while incandescent lighting was best adapted for interior use, because of its low voltage and small units of light of softer quality.

The first regular central station for incandescent lighting in the world, except that at Menlo Park, went into operation on Holborn Viaduct, London, January 12, 1882. The Pearl Street station in New York City, the first one in the United States except that at Menlo Park, and except a small Edison station in Appleton, Wisconsin, went into operation September 4, 1882.

At its inception the Pearl Street station supplied current for only four hundred lights. At the present time the New York Edison Co., the successor to the first company, organized in 1880, supplies more than 100,000 customers, wired for over 4,400,000 incandescent lamps.

In the years from 1882 on numerous companies operating under Edison patents were organized for the purpose of installing the incandescent lamp lighting system throughout the United States and in several foreign countries. The first permanent Edison station in Europe was opened at Milan, Italy, March 3, 1883, and the first one in South America at Santiago, Chile, in the summer of 1883.

The "three-wire system," which was a remarkable step in advance, was first used by Edison in the stations at Sunbury, Pa., and Brockton, Mass., in 1883.

The work of improving the incandescent lamp, now that it had become a commercial possibility, was continued by Edison and many other inventors. The first step was to lower the cost of the lamp, which in the beginning was $1.25 each per lamp. By discovering methods for producing the lamps by mechanical processes Edison cut the cost of manufacture gradually until by the fourth year in which they were made in any quantity the cost was only thirty-seven cents each. Soon afterward he reduced the cost to twenty-two cents each.

The early crude forms of incandescent lamps were rapidly followed by the fibrous carbon and other forms of high resistance carbon through many improvements up to the tantalum and tungsten lamps of to-day. The changes in material used and the heavy reduction in the cost of photometric measure still further reduced the cost of the lamps to the public, while at the same time the efficiency of the lamps was greatly increased.

The new Edison stations built to exploit the incandescent lamp method of lighting were equipped with what were known as "Jumbo" dynamos. The substituting of one large single dynamo for several small machines and of connecting this directly with the driving engine on the

same base, thus obtaining high armature speed, without separate belting, shafting and countershafting, and closer regulation, was a bold step for that day. Several of these Edison "Jumbos" were still in use up to within a few years ago. The "Jumbo" exhibited in Paris in 1881 had a capacity of only 700 lights, but was looked upon as a wonder.

Edison invented for the use of his central station the "feeder and main" system for keeping the electrical pressure uniform on all the distributing wires, without which a comprehensive distributing system for incandescent electric lighting is impractical. He also invented a practical meter for measuring current and many safety and controlling devices for his stations.

The Pearl Street station, looked upon as such a marvel in 1882, would make a striking comparison with the present modern electric station if it were still in existence. Generators of eight, ten and twelve thousand kilowatts are now found in numerous of the modern electric stations of the country, while the Northwest station of the Commonwealth Edison Company, now under construction, in Chicago, is to contain six 20,000 kilowatt turbo-generators, and the Washington Water Power Company of Spokane is now having built two units each capable of carrying 17,400 kilowatts continuously, each to be directly connected to a water wheel.

The early conflict between the arc lamp and the incandescent lamp interests was followed by the attempt to unify the two systems, resulting finally in the development of the use of the alternating current. It was in 1886 that George Westinghouse installed the first regular alternating current station in America, at Buffalo, N. Y.

One of the first steps in the development of the alternating current was that taken by a European inventor named Gaulard, who, in 1883, brought out a system of operating induction coils in series by means of which the high potential current of an alternating current generator could be delivered as low potential currents on local circuits and at

the point of consumption. William Stanley, Jr., took up the question in 1883 and 1884 and with such success that he was able to apply his discoveries, in 1886, in a commercial way at Great Barrington, Mass. While the equipment was necessarily crude, the operation was so successful as to enlist the support of George Westinghouse, with the result now known to all. Prof. Elihu Thomson and other American inventors soon after Mr. Stanley's successful work made notable improvements in the same field.

With the revolutionizing discovery, in 1888, of the rotating field principle of alternating current generators by Tesla, Stanley and other inventors in this country, and by Ferraris and others in Europe, began the actual development of alternating current apparatus. This made possible the generation of polyphase alternating currents and long distance transmission, without which the central station industry could not possibly have come to its present magnitude.

While the present central electric station and its manifold adjuncts rest upon the foundation of the work done a quarter of a century ago by Edison, Stanley, Thomson, Westinghouse, Tesla and numerous other inventors, the progress made during the last dozen years alone has been such as to make all the stations and appurtenances of the eighties and early nineties appear imperfect and incomplete. There have been changes in every aspect of the central station industry.

The most remarkable change has been brought about through the development of the high tension, long distance transmission lines. This has been largely a development of the last decade, and is more marked at the present time than ever before. The first successful commercial line in the United States transmitting current for long distance at high voltage was constructed in 1892 between San Bernardino and Pomona, California. The line was a little less than 29 miles long, and transmitted 800 horse-power at 10,000 volts, single-phase. To-day the distance over which current of high voltage can be transmitted has been increased

to approximately 210 miles, with voltage as high as 110,000 volts, while 135,000 volts is proposed.

There are numerous large electric companies which now have over 100 miles of high tension transmission lines. A partial list of these companies with the maximum voltage is given below:

Partial List of Companies Operating in United States Having Over 100 Miles of High Tension Transmission Lines

Name of Company	State	Maximum Voltage
Butte Electric & Power Co.	Montana	80,000
Central Colorado Power Co.	Colorado	100,000
Commonwealth Power Co.	Michigan	110,000
Great Falls Power Co.	Montana	100,000
Great Western Power Co.	California	100,000
Hudson River Water Power Co.	New York	30,000
Mt. Whitney Power Co.	California	34,000
Niagara, Lockport & Ontario Power Co.	New York	60,000
Northern California Power Co.	California	66,000
Pacific Gas & Electric Co.	"	60,000
Pacific Light & Power Co.	"	60,000
Pacific Power & Light Co.	Washington	66,000
Puget Sound Power Co.	"	50,000
San Joaquin Light & Power Co.	"	60,000
Seattle-Tacoma Power Co.	Washington	60,000
Sierra & San Francisco Power Co.	California	100,000
Sierra Pacific Electric Co.	Nevada	22,000
Southern California Edison Co.	California	66,000
Southern Power Co.	N. and S. Carolina	100,000
Telluride Power Co.	Colorado and Utah	40,000
Washington Water Power Co.	Washington	60,000

The Pacific Gas & Electric Company now has approximately 1,000 miles of high tension transmission lines, being the leader of all companies in the world in this respect.

The financial organization of the companies operating the electric stations has kept pace with the numerous changes in physical equipment, methods and appliances. Vast amounts of capital have been used to extend the industry in order that advantage might be taken of the new inventions and methods constantly coming to the front. This has meant both a great rebuilding of stations and a growing centralization of financial control. The rapid establishment during the last few years

of hydro-electric power transmission enterprises has been no more startling than the growth of the present great companies interested in the central station industry.

It would be most interesting if it were possible to give the exact present status of the central electric station industry. Unfortunately, the latest reliable returns are those contained in the 1907 Special Report of the Bureau of Census of the Department of Commerce and Labor. This report was compiled under the direction of Mr. Thomas Commerford Martin, a former president of the American Institute of Electrical Engineers and a prominent expert in the electrical world. Mr. Martin is also a co-author with Mr. Frank Lewis Dyer of a most enjoyable life of Edison. Both the Special Report of the Census Bureau and Messrs. Martin and Dyer's work on Edison have been freely used by the writer of the present work and he wishes to make due acknowledgment of the help thus received.

It should be stated in the beginning that the Census Bureau in its reports uses the word "station" as a synonym for "plant," although a "station," so called, may comprise two or more "plants" in a single city. The tendency toward financial and physical consolidation makes it difficult to obtain figures that fairly represent the actual number of "stations" or "plants."

In the year 1907 there were 4,714 central electric stations in this country devoted to electric light and power business. The output of these 4,714 stations for the year 1907 aggregated 5,862,276,737 kilowatt hours. This does not represent by any means the entire production of electrical energy, as the output of electric railway stations and of miscellaneous and isolated electric plants is not included. The figures hereafter submitted in this article, it should be remembered, will not include the business of the street railways and the miscellaneous and isolated stations.

In order to show the remarkable growth in the number of stations

and their equipment between the years 1902 and 1907, the following table is given:

Comparative Growth of Stations and Equipment Between the Years 1902 and 1907

	1907	1902	Increase Amount	Pct.
Number of central electric stations	4,714	3,620	1,094	30.2
Cost of construction and equipment	$1,096,913,622.	$504,740,352.	$592,173,270.	117.3
Horsepower capacity of stations	4,032,365	1,830,594	2,201,771	120.3
Kilowatt capacity of stations	2,709,225	1,212,235	1,496,990	123.5
Kilowatt capacity per station	574	334	240	71.8
Cost of construction and equipment per kilowatt capacity	$404.	$416.	....	....
Output of stations (kilowatt hours)	5,862,276,737	2,507,051,115	3,355,225,622	133.8
Output per station (kilowatt hours)	1,243,588	692,555	551,033	79.5

Aside from the growth in the number of stations the striking features of the above table are the relatively larger increase in the kilowatt capacity per station and the relatively smaller cost of construction and equipment per kilowatt capacity. This all means more efficiency and an improved service at a lower cost to the public.

Authorities believe that since the year 1907 there has been an increase of approximately 80% in the equipment and output of central electric stations, with a smaller percentage increase in the number of stations, due to larger units. Using this estimate of growth as a basis the following comparison for the years 1902 and 1911 have been made:

Comparative Growth of Stations and Equipment Between the Years 1902 and 1911

	*1911	1902	Increase Amount	Pct.
Number of central electric stations	6,000	3,620	2,380	60.5
Cost of construction and equipment	$1,975,000,000.	$504,740,352.	$1,470,259,648.	291.2
Horsepower capacity of stations	7,259,000	1,830,594	5,428,406	296.5
Kilowatt capacity of stations	4,877,000	1,212,235	3,664,765	302.3
Output of stations (kilowatt hours)	10,552,000,000	2,507,051,115	8,044,948,885	320.8

* Figures are partly estimated, actual reports for 1907 being the basis with an added 80% increase for all items except that of the number of stations, which has been approximated.

Here is a partly estimated increase in nine years' time equal to 60.5% in the number of stations, equal to 291.2% in the cost of construction and equipment, equal to 302.3% in the kilowatt capacity, and equal to 320.8% in total output. For the decade ending with the year 1910 the increase in population of the United States was equal to only 21%.

The effect of the great increase in central electric stations on the country's gas industry is of special interest. Modern improvements in electrical industry, particularly the advent of larger and more economical generating units, have so reduced the cost of electrical current, while at the same time the quality of the product has been so improved, as greatly to minimize the increase in the use of gas for illuminating purposes. This has had the effect of forcing the gas interests to push the use of their product for cooking, heating and other industrial purposes, where there is no material competition with electricity. The result has been to develop a healthy and stable condition in the artificial gas business and to afford the public the practical and economical use of both products.

It is not possible to give a comparison of the growth of the two industries over the last ten years. The Census Bureau's reports, however, show that for the five years between 1900 and 1905 the increase in the number of gas plants was equal to 16.2%; the increase in the cost of construction and equipment equal to 27.9%, and the increase in gross income equal to 65.3%.

A feature of the electric industry in which the public is particularly interested relates to private and municipal ownership. The demand for the municipal ownership of public utilities that has been made with greater or less insistence throughout the country during the last few years has caused apprehension in some quarters that private ownership of these utilities was soon to be a thing of the past. Figures at hand serve to show that, so far as the electric lighting industry is concerned, municipal ownership has not made as great headway as has private ownership.

The increase in municipal stations between the years 1902 and 1907 was equal to 53.6%, as compared with an increase of 23.4% in private stations, but the increase in kilowatt capacity of the municipal stations was only 84.3%, against an increase of 127.5% for the private stations. The increase in output of municipal stations was but 47.8%, as compared with an increase of 141.1% for private stations. The cost of construction and equipment was also much less in the case of the municipal stations. The actual number of municipal stations in 1907 was 1,252, as compared with 3,462 private stations. In 1902 there were 815 municipal stations and 2,805 private stations. While this shows a larger percentage increase in the number of municipal stations, it also shows a smaller percentage increase for municipal stations in kilowatt capacity and total output.

This would indicate that municipal ownership is making its greatest progress in small communities, where, frequently, property is taxed to pay the losses of the municipal station, and where capital would not think it worth while to enter. The small increase in kilowatt capacity of municipally owned stations shows also the effect of indifferent or political management and a lack of that energy which so characterizes the privately owned stations.

Again turning to the total number of central electric stations (other than those operated by street railways, etc., as previously explained) in operation in 1907 we find that 2,127 out of 4,714, or 45.1%, were used for purely electric commercial business. The other 2,587, or 54.9% of the total, were composite stations, that is, operated in connection with some other industry or service. The kilowatt capacity of the purely electric commercial stations was 58.1% of the total and the output of stations 63.7% of the total of all stations.

The wonderful changes in methods and equipment that have come about in the central station industry are well illustrated by a comparison

of the kind, number and kilowatt capacity of dynamos between the years 1902 and 1907, as shown in the following table:

Number, Kind and Kilowatt Capacity of Dynamos

	1907	1902	Increase Amount	Increase Pct.
Direct current, constant-voltage—				
Number of dynamos	3,680	3,823	*143	*3.7
Kilowatt capacity	406,460	330,065	76,395	23.1
Kilowatt capacity per dynamo	110.0	86.5	....	....
Direct current, constant-amperage—				
Number of dynamos	1,685	3,539	*1,854	*52.4
Kilowatt capacity	80,992	145,866	*64,874	*44.5
Kilowatt capacity per dynamo	47.5	41.0	....	....
Alternating single-phase and polyphase current—				
Number of dynamos	6,808	5,122	1,686	32.9
Kilowatt capacity	2,221,773	736,304	1,485,469	201.7
Kilowatt capacity per dynamo	326.0	143.5	....	....
Total—				
Number of dynamos	12,173	12,484	*311	*2.5
Kilowatt capacity	2,709,225	1,212,235	1,496,990	123.5
Kilowatt capacity per dynamo	222.0	97.0	....	....

*Decrease.

It is of special interest to note in the above table the much larger units in service in 1907. The total number of dynamos of all kinds was cut down by 2.5%, although there was an increase of 123.5% in kilowatt capacity. The most significant feature aside from this is the decrease of 44.5% in the kilowatt capacity of direct-current, constant-amperage dynamos and the increase of 201.7% in the kilowatt capacity of the alternating single-phase and polyphase dynamos. The greatest increase was, of course, in the alternating polyphase current, but the Census Report does not distinguish between alternating single-phase and alternating polyphase current. Were it possible to give detailed figures showing present equipment it would be found that even more startling changes have been made since 1907 than were made between the years 1902 and 1907.

Passing to a consideration of primary power some impressive figures

are found. They show in a graphic way the wonderful increase in the last decade in the use of water power generated current. The growth in the past in this respect, however, is nothing compared with what it should be in the years to come.

Mr. Sidney Z. Mitchell, president of the Electric Bond and Share Company, in an address recently delivered at a public hearing held under the auspices of the Transmission Section of the National Electric Light Association, pointed out that the use of water power sites for electric generating purposes unfortunately has been in the past and still is greatly retarded by inappropriate laws and in some cases total lack of laws. As a result, developers of water power cannot obtain definite and reasonable tenures such as to justify the expenditure of capital for development. This applies particularly to the development of water powers upon navigable streams and especially where the fee to the necessary lands rests with the Federal Government.

Another serious difficulty in the way of getting capital for such development is that in practically all cases the water is owned by the state in which it is located, thus subjecting those who develop the power to the regulation of two masters, namely, the state, as to the water, and the Federal Government, as to the law. The fact that one government may pass laws that a corporation shall conduct its business in a certain way and in no other way, and another and equally potent government may pass laws requiring the same corporation to do a public service business in a different way, needs only to be stated to show that such conflict of laws is fatal.

Mr. Mitchell, like other students of the question, believes that real conservation of water power means the use of water power. And yet the question of control between the Federal Government and the several states in which are located the undeveloped water power, together with the antagonism against capital so frequently found, is denying to the

public the right to use the water power found in such great quantities in various sections of the country and without doubt is retarding the natural growth of the country.

While these obstacles in the way of providing the necessary capital for water power development affect many water powers on navigable streams and upon the public domain, especially in the newly opened sections of the West, it must be remembered that there are many water powers available whose use do not include dealings with the Federal Government and where permanent fee titles are obtainable free from any legal complications. Where these conditions prevailed, there was a tremendous increase in water power development during the years between 1902 and 1907, this being the period during which was begun the development in the high tension, long distance transmission of hydro-electric energy. A comparison of the various kinds of primary power for the years 1907 and 1902 follows:

Comparison of Primary Power

	1907	1902	Increase. Amount	Increase. Pct.
Number of stations	4,714	3,620	1,094	30.2
Total number of machines	10,150	7,485	2,665	35.6
Horsepower capacity:				
Steam engines and steam turbines	2,627,450	1,379,941	1,247,509	90.4
Gas engines	55,828	12,181	43,647	358.3
Water wheels	1,349,087	438,472	910,615	207.7
Total horsepower capacity	4,032,365	1,830,594	2,201,771	120.3
Total horsepower capacity per station	855	506	....	....
Total horsepower capacity per machine	397	184	....	....

The fact that during the five-year period the percentage increase in water power was considerably more than double the percentage increase in steam power, is highly significant of the trend of the times. Naturally, the largest percentage increase in kilowatt capacity was in those more newly developed sections of the country where water-power

sites had not been previously utilized. While the water powers of the Eastern States have been more thoroughly and completely developed than those of the Western States, it must be remembered that the greater portion of the developments in the older sections of the country were made for driving factories located at the power sites before the electric transmission of energy had become commercially practicable. In the older sections factories were brought to the power sites, whereas in the later developments of the newer sections of the country the more economical and convenient method was adopted of generating electric power by water and transmitting it over wide areas to points where it could be more conveniently and economically used.

The ten states showing the greatest percentage increase in kilowatt capacity are shown herewith:

The Ten States in Which Kilowatt Capacity of Central Electric Stations Showed Greatest Percentage Increase in Years from 1902 to 1907

Kilowatt Capacity

	Actual 1907	Actual 1902	Increase Actual	Increase Pct.
Washington	66,308	13,679	52,629	384.7
Georgia	35,446	7,620	27,826	365.2
South Carolina	51,271	13,390	37,881	282.9
Minnesota	78,516	20,999	57,517	273.9
Kansas	30,307	8,596	21,711	252.6
Oregon	32,587	11,165	21,422	191.9
California	238,480	83,816	154,664	184.5
Maryland	36,223	13,207	23,016	174.3
New York	482,031	187,252	294,779	157.4
Maine	39,290	15,291	23,999	156.9

It will be noted that the above table shows New York ninth in the list of States in point of percentage increase in kilowatt capacity, although it leads all other States in the actual increase in kilowatt capacity. This is undoubtedly due principally to the developments of Niagara Falls and to the transit improvements in New York City.

In order to show the ten states in which the actual increase in total kilowatt capacity was the greatest between the years 1902 and 1907 the following table is given:

The Ten States in which Kilowatt Capacity of Central Electric Stations was the Greatest in 1907, with a 1902 Comparison

Kilowatt Capacity

	1907	1902	Increase Amount	Increase Pct.
New York	482,031	187,252	294,779	157.4
California	238,480	83,816	154,664	184.5
Pennslyvania	212,543	121,388	91,155	75.1
Illinois	209,226	100,320	108,906	108.6
Massachusetts	135,924	90,624	45,300	50.0
Ohio	126,533	69,811	56,722	81.3
Michigan	101,714	44,176	57,538	130.2
Indiana	81,576	38,144	43,432	113.9
Minnesota	78,516	20,999	57,517	273.9
New Jersey	70,566	46,120	24,446	53.0

The last two tables given and the two which will follow show clearly, among other things, that the greatest expansion in the development of electric power has been in the South and the West, the progress in the Eastern States having been relatively less marked. The State of New York retained first place among all the states in respect to the actual increase in kilowatt capacity, but in point of percentage increase occupied only ninth place. The State of Washington acquired first place among all the states in respect to the percentage increase in kilowatt capacity, although its actual kilowatt capacity in 1907 was so small as not to give the state a place among the first ten having the largest kilowatt capacity.

The two last tables and the remarks following them should be considered in connection with the following table showing the ten states in which the output of stations was the greatest:

The Ten States in Which Output of Stations Was Greatest in 1907, with a 1902 Comparison

Output of Stations (Kilowatt Hours)

	1907	1902	Increase Amount	Increase Pct.
New York	1,452,222,471	701,769,716	750,452,755	106.9
California	661,606,309	152,728,042	508,878,267	333.2
Illinois	467,657,328	161,543,646	306,113,682	189.5
Pennsylvania	416,554,167	241,094,328	175,459,839	72.8
Washington	257,785,236	19,722,262	238,062,974	1,207.1
Massachusetts	219,425,607	125,813,392	93,612,215	74.4
Ohio	217,311,924	127,437,383	89,874,541	70.5
Michigan	208,154,199	80,564,630	127,589,569	158.4
Missouri	147,328,446	57,450,731	89,877,715	156.4
New Jersey	140,527,522	78,739,456	61,788,066	78.5

Naturally, the remarkable showing of the State of Washington will first attract the attenion of the reader. An increase in output of stations in five years equal to 1,207.1% is such an advance as to be startling. It will be noticed also that, while the State of Washington held fifth place among all the states in 1907 in point of output, its output in 1902 was so very small as to put it far in the background. It will be recalled that a previous table showed the State of Washington in first place among all the states in respect to the percentage increase in kilowatt capacity during the five year period between 1902 and 1907. Evidently this state is going to play a much greater part in power development in the years to come.

The following table shows a comparison of the increase in kilowatt capacity and the population by districts:

Central Electric Stations by Geographic Divisions in Comparison with the Increase in Population

	1907	1902	Increase Amount	Increase Pct.
North Atlantic—				
Number of stations	1,070	913	157	17.2
Kilowatt capacity	1,054,528	517,549	536,979	103.8
Population	23,779,013	21,778,196	2,000,817	9.2
South Atlantic—				
Number of stations	390	251	139	55.4
Kilowatt capacity	195,309	62,301	133,008	213.5
Population	11,574,988	10,770,414	804,574	7.5
North Central—				
Number of stations	2,095	1,706	389	22.8
Kilowatt capacity	805,012	375,514	429,498	114.4
Population	29,026,645	27,087,206	1,939,439	7.2
South Central—				
Number of stations	679	404	275	68.1
Kilowatt capacity	165,969	82,259	83,710	101.8
Population	16,368,558	14,651,535	1,717,023	11.7
Western—				
Number of stations	480	346	134	38.7
Kilowatt capacity	488,407	174,612	313,795	179.7
Population	4,783,557	4,289,085	494,472	11.5
Total United States—				
Number of stations	4,714	3,620	1,094	30.2
Kilowatt capacity	2,709,225	1,212,235	1,496,990	123.5
Population	85,532,761	78,576,436	6,956,325	8.9

The above geographic divisions are rather arbitrary and it would seem that, in order to get a more comprehensive view of the important subject of increase in population as compared with increase in kilowatt capacity, more subdivisions should be given. The Western division, for example, includes all the territory West of a line drawn from the Northwest corner of North Dakota to the Southwest corner of Texas. Despite the rather broad lines on which the table is laid out it is interesting as again emphasizing the great growth in electrical development going on in the Western part of our country.

Turning to the discussion of the financial questions involved in the consideration of the central electric stations it is well first to point out the progress made between the years 1902 and 1907 in increasing the net revenue from operations as compared with the cost of construction and equipment. This is shown in the following table:

Relation of Earnings to Cost of Construction and Equipment

	1907	1902	Increase Amount	Increase Pct.
Number of central electric stations	4,714	3,620	1,094	30.2
Cost of construction and equipment	$1,096,913,622.	$504,740,352.	$592,173,270.	117.3
Gross income	175,642,338.	85,700,605.	89,941,733.	104.9
Pct. of gross income to cost of construction and equipment	16.0%	16.9%	......	....
Total expenses	$106,205,149.	$55,457,830.	$50,747,319.	91.5
Pct. of total expenses to cost of construction and equipment	9.7%	11.0%	......	....
Net operating revenue	$69,437,189.	$30,242,775.	$39,194,414.	129.6
Pct. of net operating revenue to cost of construction and equipment	6.3%	5.9%	......	....

It will be noticed in the above table that, while in 1907 there was a slightly smaller percentage of gross income to cost of construction and equipment than in 1902, the total expenses were so much smaller as to bring about a substantial increase in the percentage of net operating revenue to cost of construction and equipment, a most gratifying fact, especially when it is realized that prices charged the public were on a constantly declining scale.

This indicates more modern and better insulations and speaks well for the efficiency with which the business was conducted. A percentage of net operating revenue to cost of construction and equipment of only 6.3% is not large to be sure, but it is an excellent showing for an industry so new. With a leeway of 6.3% it was possible for the companies operating these stations, considered as a whole, to meet interest charges and to make payments of dividends on a substantial part of the total capital stock.

If the total gross income of the stations now in operation be estimated as larger by 80% than it was in 1907, and if the cost of construction and equipment also had increased by the same percentage, the total gross income for 1911 would aggregate $316,156,208, and the percentage of income would, of course, continue at 16%. It is most reasonable to believe, however, that there has been a larger percentage increase in income than in cost of construction; likewise a smaller percentage increase in total expenses. Accordingly, if actual figures for 1911 were at hand it would no doubt be found that both the percentage of gross income and the percentage of net revenue to cost of construction and equipment would now make an even more favorable showing than they did in 1907.

The amount of capital invested in central electric stations the last decade has run into most impressive figures. The total outstanding bonds and stock of all commercial companies engaged in the central electric station industry (exclusive, of course, of street railways, etc.) in 1902 aggregated $627,515,875. At the present time this capitalization, partly estimated, totals $2,415,591,327. This is shown in the following table:

Total Capitalization of Commercial Companies Only

			Increase	
	*1911	1902	Amount	Pct.
Bonds outstanding..............	$1,081,219,833	$254,563,923	$826,655,910	324.7
Total stock outstanding..........	1,334,371,494	372,951,952	961,419,542	257.7
Total bonds and stock outstanding..	2,415,591,327	627,515,875	1,788,075,452	284.9

*Figures are partly estimated, actual reports for 1907 being the basis with an added 80% increase.

In order to obtain satisfactory comparisons only commercial companies are considered in the tables on capitalization which follow, showing actual figures for 1907 and 1902. The first table shows the outstanding bonds and the interest charges paid.

Outstanding Bonds and Interest Charges of Commercial Companies Only

			Interest	
	1907	1902	Amount	Pct.
Bonds outstanding	$600,677,685.	$254,563,923.	$346,113,762.	136.0
Interest charges	26,842,330.	12,118,740.	14,723,590.	121.5
Pct. of interest charges to funded debt	4.47%	4.76%	....	.....

The bonded debt for 1907 shown in the above table covers 1,129 companies, that being the number of commercial companies having bonds outstanding in that year. Of these companies all but 51 paid interest on their bonded debt in 1907. Those 51 companies not paying interest had outstanding bonds amounting to only $9,270,800 out of the total of $600,677,685.

It will be immediately realized that the showing of the percentage of interest charges to funded debt for 1907 cannot be an absolutely true showing inasmuch as the majority of electric light and power company bonds bear interest at the rate of at least 5%. It is well to state, therefore, that the amount shown as interest on bonds outstanding is not the total interest chargeable for the year, due to various reasons, notably, to the fact that it is customary practice to charge all or a part of the interest to plant account while construction of plant is under way. The outstanding bonds in 1907 included, of course, many bonds issued for the construction of plants not yet completed.

The fact that nearly 4½% was paid on total bonds outstanding in the year 1907, notwithstanding an increase of 136% in the amount of bonds outstanding, as compared with 1902, shows the general stability of the central station industry. This is even more clearly emphasized in the following table giving the outstanding capital stock and the dividends paid:

Outstanding Capital Stock and Dividends Paid of Commercial Companies Only

			Increase	
	1907	1902	Amount	Pct.
Preferred stock outstanding..........	$75,313,725.	$23,871,671.	$51,442.054.	215.5
Preferred stock dividends.............	2,416,760.	629,496.	1,787,264.	283.9
Pct. of dividends to stock..............	3.21%	2.63%	....	....
Common stock outstanding...........	666,003,772.	349,080,281.	316,923,491.	90.8
Common stock dividends..............	16,883,812.	5,560,341.	11,323,471.	203.6
Pct. of dividends to stock..............	2.53%	1.59%	....	....
Total stock outstanding..............	741,317,497.	372,951,952.	368,365,545.	98.8
Total dividends......................	19,300,572.	6,189,837.	13,110,735.	211.8
Pct. of total dividends to total stock....	2.60%	1.66%	....	....

It will be noted that there was a much greater relative increase in outstanding preferred stock than in outstanding bonds, the increase in the preferred stock being equal to 215.5% and that in bonds 136%. The increase in common stock was equal to 90.8%. This reflects the modern tendency of financing a material portion of the growth of electrical companies by the issuance of preferred stock instead of by the old and impractical method of providing for all additional cash requirements through the sale of bonds.

It will be noted that the total dividends paid in 1907 were equal to 2.60% on the total capitalization, as compared with 1.66% paid in 1902.

The total outstanding capitalization—bonds and stocks—and the total interest and dividends paid in 1907, with a 1902 comparison, are shown in the following table:

Total Capitalization, Interest Charges and Dividends of Commercial Companies Only

	1907	1902	Increase Amount	Increase Pct.
Number of companies.........	2,516	2,049	467	22.8
Bonds outstanding	$600,677,685.	$254,563,923.	$346,113,762.	136.0
Total stock outstanding........	741,317,497.	372,951,952.	368,365,545.	98.8
Total bonds and stock out......	1,341,995,182.	627,515,875.	714,479,307.	113.8
Total interest and dividends paid	46,142,902.	18,308,577.	27,834,325.	152.0
Pct. of total interest and dividends paid to total capitalization outstanding.	3.44%	2.92%	....	.....

Of the 2,516 companies considered in the above table for the year 1907 a total of 1,496 paid either interest or dividends on $1,275,469,707 total capitalization—bonds and stocks—while 1,020 companies paid neither interest nor dividends on $66,525,475 total capitalization.

It will thus be noted that the companies which failed to pay both interest and dividends were the smaller companies, inasmuch as interest or dividends were paid on 95% of the total amount of outstanding capitalization. It is true that 40% of the companies failed to pay both interest and dividends, but the total capitalization of these companies amounted to only 5% of the total capitalization of the 2,516 companies. Dividends were paid on 59.5% of the total preferred stock outstanding and on 48.3% of the total common stock outstanding. The average rate of divi-

dends paid on the dividend-paying preferred stock was 5.39%, and on the dividend-paying common stock was 5.25%.

These figures point plainly enough to the security of investments of electric light and power companies. If it were possible to present exact tables of capitalization and interest and dividend payments showing results for the current year it would be found, without question, that the electric light and power business is now on an even stronger footing than it was in 1907. It is a better realization of these facts that has been responsible for the unusually excellent demand for electric company securities the last few years.

A recapitulation, in small part, of all the foregoing presents the following impressive statements:

Beams of intense electric light obtained from the voltaic arc by Faraday in 1858.

First dynamo electric machine patented by Gramme in 1870.

Jablochkoff's arc lamp invented in 1876.

Wallace-Farmer dynamo at the Philadelphia Centennial Exposition in 1876.

First commercial arc lamp system (Brush) installed in 1879.

First complete system of incandescent lighting at Menlo Park in 1879.

First commercial central station for incandescent lighting began operation in London in 1882.

Pearl Street Station of Edison Electric Illuminating Co. began operation in New York in 1882.

"Feeder and main" system used in 1883.

"Three-wire system" first used in 1883.

First regular alternating current station was installed at Buffalo by George Westinghouse in 1886.

Rotating field principle of alternating current generators, making possible the present modern electric industry, discovered in 1888.

Number of central electric stations, exclusive of street railway and miscellaneous stations, in the United States in 1911 estimated at 6,000.

Cost of construction and equipment of these stations estimated at $1,975,000,000.

Horse-power capacity of these stations estimated at 7,259,000.

Kilowatt capacity of these stations estimated at 4,877,000.

Output of these stations in 1911 estimated at 10,552,000,000 kilowatt hours.

Number of incandescent lamps that will be manufactured in 1911 estimated at 90,000,000.

Estimated gross income of stations in 1911 estimated at $316,156,208.

Percentage of gross income to cost of construction and equipment, for 4,714 stations, in 1907 was 16%, that is, the investment of six dollars in plant account was necessary for every dollar of gross income received.

Percentage of net operating revenue to cost of construction and equipment, for 4,714 stations, in 1907 was 6.3%.

Total bonds and stock of commercial companies in 1911 estimated at $2,415,591,327.

Total bonds outstanding of commercial companies in 1907 was $600,677,685.

Percentage of interest charges on these bonds in 1907 was 4.47%.

Total preferred stock outstanding of commerial companies in 1907 was $75,313,725.

Percentage of dividends paid on this preferred stock in 1907 was 3.21%.

Total common stock outstanding of commercial companies in 1907 was $666,003,772.

Percentage of dividends paid on this common stock was 2.53%.

Total outstanding bonds and stock of 2,516 commercial companies in 1907 was $1,341,995,182.

Percentage of total interest and dividends paid on this capitalization in 1907 was 3.42%.

Preferred dividends were paid in 1907 on 59.5% of the total preferred stock.

Common dividends were paid in 1907 on 48.3% of the total common stock.

These are the facts that demonstrate the vast influence the electric light and power industry has had upon the country's industrial growth the last quarter of a century—a period of time in which there has been by far the greatest material progress ever witnessed in any country. These facts also indicate the wonderful growth in the industry that is to take place in the years to come.

It is not too much to expect that in the future the securities of electric companies will occupy first place, both as to volume and stability, among investments of all classes. The electric age is with us and will steadily become more pronounced with the years. The securities of the companies engaged in the great work afford most attractive investment possibilities.

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